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Selenology and Cosmogeology. Cosmic and Geologic Import of the Lunar Features: DR. HERMAN L. FAIRCHILD 555

Scientific Events:

Intellectual Freedom; The Association of Scientific Workers; The Annual Meeting of the Union of American Biological Societies; Geophysics as Applied to Continental Structure. Recent Deaths and Memorials 562

Scientific Notes and News 565

Discussion:

What is Soil?: PROFESSOR W. F. GERICKE. *Are there Different Critical Oxygen Concentrations for the Different Phases of Root Activity?:* PROFESSOR DAMON BOYNTON, J. DEVILLIERS and WALTER REUTHER. *A Peculiarity of Pigmentation of the Upper Arm of Negroes:* DR. PALMER HOWARD FUTCHER. *Additional Records of Hippoboscidae from Mourning Doves:* DR. JAMES M. BRENNAN. *The Teaching of Botany in American Colleges and Universities:* DR. E. L. STOVER 568

Societies and Meetings:

The International Congress of Mathematicians 571

Reports:

Grants for Research of the American Philosophical Society 572

Special Articles:

Identification of the Filterable Transmissible Neurolytic Agent Isolated from Toxoplasma-infected Tissue as a New Pleuropneumonia-like Microbe: DR. ALBERT B. SABIN. *The Life-Maintaining Effect of Crystalline Progesterone in Adrenalectomized Ferrets:* DR. ROBERT GAUNT and HARRY W. HAYS. *Nicotinic Acid and the Growth of Isolated Pea Roots:* FREDRICK T. ADDICOTT and DR. JAMES BONNER 575

Science News 8

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SELENOLOGY AND COSMOGEOLOGY

COSMIC AND GEOLOGIC IMPORT OF THE LUNAR FEATURES

By Dr. HERMAN L. FAIRCHILD

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APOLOGY: In slight excuse for trespassing in the astronomic field it may be said that a geologist, cooperating with an astronomer, showed the fallacy of the nebular hypothesis, which had been cherished by astronomers and selenographers for more than a century; and that a student in geology may have some reasonable ideas in selenology.

Thesis: The basins and pittings of the lunar surface are impact craters and are ocular confirmation of the view that the planets and satellites were built by cold accretion. This implies acceptance of the planetesimal hypothesis of Chamberlin and Moulton. The genesis, growth, history and structure of the earth and moon are here considered from the planetesimal view-point.

Ever since Galileo first peeked at the moon through his crude telescope, the lunar surface has been perhaps the most singular, fascinating and puzzling of telescopic objects. Galileo's surprise and delight have been reexperienced by all observers, and for four centuries selenography has been a favorite pastime for sky-gazers. Description and portrayal of the so-called craters and of the plains, mountains and the many peculiar features make an extensive literature. In recent time photography has largely displaced pen and pencil. Naturally the moon has been the subject of much speculation and imaginings and the cause of superstition and mental aberration. Scientific literature includes much lunar description that is unscientific and even unreasonable. The most pretentious treatise on the moon in American literature argues for the existence on the moon of atmosphere, snow, ice and vegetation. This ignores the heated condition of the surface during the long lunar day. It would be a new

sort of vegetation that could endure the great extremes of temperature between the lunar day and night. With all this interest in and study of the moon, the origin of its striking features yet remains in question.

LUNAR CRATERS

The most important error in the lunar study relates to the so-called craters. Until later years the tens of thousands of pittings and circular depressions have been quite universally regarded as of explosive or volcanic origin. The volcanic conception was naturally involved in the erroneous nebular hypothesis to be described below. Volcanism seemed to be the natural or even inevitable stage in the cooling of a molten globe. However, with the exception of the circular form of the basins and the supposed resemblance of the lunar substance to volcanic scoria, it is questioned if there is a single feature of the moon's surface that simulates or illustrates volcanism as we find this upon the earth. A casual resemblance of the lunar features to terrestrial volcanic craters was accepted as proof of volcanism, and the negative facts and philosophy were neglected. The evidence and argument in negation of lunar volcanism and the rational substitute will be considered later in this writing. The study of the moon, selenology, has been retarded by adherence to a mistaken conception of planetary genesis. The same is emphatically true of geology, which held the belief that the earth was originally a molten, incandescent sphere. Most serious problems in geology refer, in their final analysis, to the manner of formation of the earth. It is desirable now to review briefly the astronomic element in our earth science.

NEBULAR, LAPLACIAN, HYPOTHESIS

This hypothesis postulated that the material of the solar system was originally a discoid or wheel-shaped nebula of superheated gas with rapid revolution. By centrifugal force successive rings were detached, which in some manner evolved the planets; the sun being the undistributed central mass. This hypothesis required that all the planets, planetoids and satellites should pass from a superheated gaseous condition through a molten state. This conception, which involved a molten incandescent earth, was universally accepted for a hundred years down to the close of the last century. Yet the conception was not true. It remained for a geologist with the collaboration of an astronomer to prove its fallacy. They found that the Laplacian conception failed at every point where it was tested by modern physics.

PLANETESIMAL HYPOTHESIS

As a substitute for the mistaken hypothesis Professor T. C. Chamberlin with Professor F. R. Moulton formulated in the year 1900 the planetesimal hypothesis. This new conception holds that the materials which constitute the planets, planetoids and satellites were derived from the sun through gravitational effect by a passing star. The combination of forces and movements involved in the dynamic encounter threw the expelled and disseminated solar material into orbital revolution around the parent body.

Under this hypothesis the planets and satellites, including of course the earth and moon, were formed by a process of cold accretion. They were built up from nuclei by ingathering through overtake and intake of solar material, bodies large and small, the "planetesimals" all traveling in the same general direction in various orbits about the sun.

OTHER COSMIC HYPOTHESES

The astronomers and astrophysicists finally accepted the death sentence on the Laplacian conception; and some of them soon formulated their own hypotheses as rivals or substitutes for the planetesimal. During the last thirty-five years the considerable literature on the subject records many changes and revisions in the hypotheses. Like the planetesimal, these conceptions are all based on assumptions.

In his recent book, "The Solar System and Its Origin," Professor H. N. Russell has briefly reviewed the several hypotheses of the genesis of the solar system and concludes with these words, "The most encouraging direction for this attempt would still appear to be in the modification of the hypothesis of an encounter." We may claim that the planetesimal hypothesis yet stands with the simplest assumption and the most reasonable sequence of process and events.

Our planetary system had a biparental origin. The father star passed on his way with calm indifference, leaving to the mother sun the responsibility of training her brood and bringing it into the present orderly and stable system, the solar family, as Chamberlin aptly called it.

ORIGIN OF THE EARTH

The astronomic philosophy covering the origin of the planetary system has relation to fundamental geologic philosophy.

The conception of an originally molten earth was inherent in and necessitated by the nebular hypothesis, and down to forty years ago our earth science was based on the conception of an originally molten globe. With the passing of the nebular hypothesis the molten-globe idea should have been discarded as having no factual basis. Yet the idea was so imbedded in scientific thought and literature that it survives and yet appears in scientific writings.

The question might be asked: Could not the earth have been originally molten under some conception of

the origin of the planetary system other than the nebular hypothesis? Under any conception of planetary origin thus far proposed the answer is fairly negative. It is now generally recognized that the planetary system is composed of materials derived from the sun and that its present form is the product of an organizing process acting through vast eons of time. Concerning the origin of the earth only two conditions seem possible. Either it was born with full volume and mass or else it grew by some manner of accretion. Whatever was its origin and history the same must be attributed to all the other planets. The earth could not have been unique.

If the earth, derived from the solar atmosphere, held at once as a gaseous globe all the substance of the present earth, then a similar condition was true of all the planets. Such initial concentration of nearly all the substance of the planetary system is not only highly improbable, but it would be quite impossible to trace its evolution into the dynamics and structure of the existing system.

If the earth was built by accretion and yet was molten when completed, then the ingathered materials had retained their solar heat during all the vast lapse of time necessary for the accretionary process. This seems impossible. The solar substance drawn from, or expelled from the sun was thrown far out into interstellar space. (Pluto is over three and one-half billion miles from the sun.) This gaseous material was subjected to the absolute zero temperature in the vacuum of space. It must promptly have been condensed to fluid and eventually to the solid state. Astronomic science does not truly favor in fact or philosophy the conception of a molten earth.

Discussion of the genesis of the solar system during the past thirty-seven years has left the Chamberlin-Moulton planetesimal hypothesis as the one with the least assumption and the most reasonable, simple and satisfactory conception yet proposed, and the one most in harmony with geologic facts. Geology favors the cold accretion theory.

Absence of Lunar Volcanism

The many singular features of the lunar surface were attributed to volcanism in the absence of any other scientific explanation, and the physical characters in negation of volcanism were not properly considered. One of the latter relates to the moon's structure.

The earth and the moon, built of planetesimals, have similar composition. The only materials on the earth with which the moon's substance may be compared, and only by ocular and spectroscopic means, are the volcanic scoria and lavas, which do have superficial resemblance. The exterior mass of the earth, to a depth of quite two thousand miles, has been subjected to the alterative work of water and air, producing materials and structures entirely absent on the moon. The lunar substance is the unoxidized, unhydrated, unaltered planetesimal stuff. The name "lunite" will now be used.

The earth's exterior mass is compact, solid rock. Through fissures in the crust and by outflow of molten magma some large part of the earth's imprisoned gases, the magmatic volatiles, found slow and quiet escape. Some part escaped imprisonment by violence, producing volcanoes. On the earth's entire surface volcanism is a rare and widely scattered feature. Unlike the earth the moon has no compact rock strata. Being gravitationally incompetent to hold gases on its surface, it never had an atmosphere and ocean. Whatever was the genesis of the moon, its surface material has never been compacted by water action, sedimentation.

The moon's substance has been generally described as scoria. Temperature measurements indicate that the material is highly porous. It thus appears that the surface material is relatively incoherent. Its nature is evidently what would be expected from accumulation through planetesimal accretion. Undoubtedly the moon inherited in its solar substance its proper share of volatile elements, and these volatiles must have found easy escape. The magmatic vapors of the lunar body were able to escape with relative ease through the uncompacted surficial mass, and no cause or condition is found for explosive phenomena.

Meteor Crater

The only feature on the earth with which the lunar craters may be compared is Meteor Crater in north-central Arizona.[1] Involving complex problems in kinetics, mechanics, meteorology and geology, this was declared, by the great Arrhenius, to be the most interesting spot on the earth.

The present concern is with the impacting body, meteorite or comet, and the disposition of its energy and mass, and also with the effects and phenomena of the impact. This requires a fair description of the crater-basin in all its features.

We do not know if the impacting body in this Arizona encounter was a member of our solar system, only a belated planetesimal, or was a visitor from interstellar space arriving in haste unannounced and without credentials.

This crater is a great circular basin, in hard rock

[1] G. K. Gilbert, SCIENCE, 3, 1896; D. M. Barringer, *Proc. Acad. Nat. Sci. Phila.*, December, 1905; B. C. Tilghman, *ibid.*; H. L. Fairchild, Geol. Soc. Amer., *Bull.* 18, 1907, and SCIENCE, 72, 1930; Eliot Blackwelder, SCIENCE, 76, 1932; Clyde Fisher, Amer. Mus. Nat. Hist., Guide Leaflet Series, No. 92.

strata, now 4,000 feet in diameter and with a depth of 600 feet, of which about 150 feet is due to uptilt of the rock rim. An inwash filling has average depth of about 80 feet. The rock strata belong in the Grand Canyon series. In descending order, with approximate thickness they are, Moencopie red sandstone, 40 feet; Kaibab limestone, 260 feet; Coconino white sandstone, 950 feet.

At the time of impact the spaces and interstices of the upper strata were filled with air and water, while the Coconino sandstone was saturated with water.

The tremendous concussion shivered the rocks to dust for a depth 1,200 feet or more.

The underground form of the shivered rock was that of a "cone of percussion." Taking the angle of the cone as ninety degrees and assuming that the impacted area on the surface of the plain was a circle of 1,000 feet diameter, then the downward enlargement of the cone would, at the depth of 1,200 feet, give a diameter of quite 3,500 feet.

The short-wave vibrations pulverized the quartz grains of the Coconino to microscopic dust and produced heat sufficient to fuse some of the quartz into silica glass.

The water in the pulverized and vibrating mass was instantly changed to superheated steam, and the violent expansion lifted not only the crushed rock but also the overhanging shattered strata and piled part of the mass on the plain, while the larger part fell back into the instantly created basin.

Further explosive effect uptilted the topping strata of the basin rim. During subsequent time the upper portion of the walls has receded somewhat by weathering, as indicated by the talus slopes. The remnant of the tilted strata has a maximum upslant of about 150 feet.

The ring of rock debris on the crater rim is a great ridge with a basal width of nearly one-half mile. It consists of quartz flour, the powdered Coconino sandstone and fragments of Kaibab limestone. Larger blocks of the latter have been estimated in weight up to 4,000 tons, and huge blocks of this limestone lie a mile from the crater. The ridge of debris has been reduced in volume by rain and wind erosion.

The amount and weight of rock expelled from the crater-basin is fairly determined. Drilling in the crater penetrated 800 feet down to the red Supai sandstone, of which 80 feet is inwash filling. The 720 feet deducted from 1,250 feet, the depth of the three rock formations, leaves 530 feet as the depth of the primitive crater basin below the surface of the plain. The same figure is found by deducting 150 feet of uptilt of the rock rim from the 600 feet of basin depth and adding the 80 feet of inwash filling.

The expelled rock was a discoid of stone with diameter about 3,500 feet and thickness of 530 feet. The weight was about 400,000,000 tons. The energy expended in tossing this mass to the plain was a minor portion of the energy transferred from the meteorite to the earth.

Transformation of Energy

The dynamics involved in the production of the crater give a fine illustration in conservation and transformation of energy. The resident energy in the falling meteorite, mass-motion, was partly transferred to the earth and transformed into vibratory motion. This was all transformed into molecular motion or heat and this was retransformed through steam expansion into mass motion, the lifting of the great mass of rock through hundreds of feet against the force of gravity. To-day part of that energy is stored in the great ring of rock rubbish on the rim of the crater as potential energy, by virtue of its uplifted position.

All the kinetic energy of the meteorite was not transferred to the earth, as a large part was used in its self-explosion, noted below. The collision, the transformation of energy, the explosion deep in the earth and the bursting of the meteorite all occurred in a second of time.

Some of the substance of the meteorite, exploding simultaneously with the crater eruption, is found in the crater filling.

Canyon Diablo Irons

On the plain surrounding Meteor Crater in a radius of four to five miles have been found thousands of nickel-iron meteorites, the Canyon Diablo siderites. They range in weight from 1,406 pounds down to tiny individuals of a few grams. Their character, number, size and association make this "fall the most famous and interesting in the literature of meteorites."

The irregular form of the irons, with great angularity and sharp cusps and ridges, shows that they were nodular accretions in a non-metallic substance, probably meteoritic stone. It appears likely that most if not all solid iron meteorites were originally inclusions in stony matrix. The Willamette iron in the American Museum of Natural History with its perforations is a fine example. The genetic relationship of the Canyon Diablo irons to Meteor Crater is positive. The irons were nodular inclusions in either the giant meteorite or in stony masses which were attached to the great nucleus. Stone-like meteorites, the aerolites, are highly perishable, and exposed to air and water dissolve and disappear. The giant meteorite and its companions, if it had such, undoubtedly were largely stony substance which disappeared thousands of years ago, leaving the irons and the crater features as the record. It has been suggested that the irons were

unattached or free companions of the meteorite. This idea probably is in error. The irons with their stony casings did not fall directly from the sky or vertically. Such fall would imply that the thousands of bodies had been traveling through space as a great open swarm or cluster ten miles in diameter; which would seem impossible. Gravitation would draw the bodies together into a close, compact mass. Atmospheric obstruction during their fall to the earth could not so widely separate the units. The impact of such assumed close aggregation would have quite the same effect as if it were one solid body. The kinetic energy changed instantly to heat produced expansion with violent explosion which distributed the entire mass over a circle of five miles radius. The sharp edges and angles of the nickel-irons prove that they were not heated sufficiently to produce any fusion. This fact is also emphasized by the occurrence of innumerable minute irons.

Fate of the Meteorite

The fate of the meteorite is the interesting and important question. This has already been suggested in the explanation of the Canyon Diablo irons.

Exploration of the crater was made in the belief that a great nickel-iron mass lay buried. This is mechanically impossible.

Physicists claim that in the sudden stoppage of a great meteorite with planetary velocity, the kinetic energy, mass motion, would produce heat sufficient to vaporize the mass. This appears to assume that all the energy is expended upon the mass itself. But at Meteor Crater all the enormous energy represented in the crushing of the strata and the expulsion to produce the basin was transformed energy supplied by the meteorite. The explosion of the meteorite was in quite the same instant of time as the impact and concussion. A moment later came the piling on the plain of the disrupted rock. It is probable that some part of the meteorite lies beneath the great ring of rock debris surrounding the crater. Such burial probably has preserved some meteoritic stone of which the meteorite was mostly composed.

In any physical and mathematical study of the transformed energy the enormous amount consumed or utilized in the expansion, and in the projection and spreading of the mass over the area of ten miles in diameter, must be recognized, as well as that utilized in the production of the crater phenomena.

If the impacting body was a spherical siderolite, of 1,000 feet diameter, and with an average density of 4.0, then its weight was 65,450,000 tons.

Lunar Craters of Impact Origin

The lunar craters are mostly deep depressions below the general surface, even to a depth of 10,000 feet, and it is now recognized that the lunar depressions are impact craters, produced by the infall of bodies of undetermined nature and velocity. Many of the craters have a central cone, a feature readily duplicated in experimentation. The sharp-pointed or spire form is undoubtedly due to spalling or exfoliation of the massive original columns, caused by expansion and contraction of the lunite under the extremes of temperature.

The multitude of craters and ringed plains many thousands in number, sometimes closely crowded and overlapping and of varying size up to fifty miles or more in diameter, is a remarkable and strange display, but this is precisely the condition and appearance theoretically required during the early stage of planetary growth by ingathering of planetesimals.[2]

The moon is ocular evidence for the cold accretion element in the planetesimal hypothesis.

Fate of Lunar Planetesimals

Between Meteor Crater and the lunar impact craters there are great differences, due to the uncompacted character of the lunar surface material and to the varying size of its impact features, ranging from barely visible pittings up to ringed plains with diameter of sixty miles. Planetesimals are supposed to have ranged in size from dust particles to bodies the size of planetoids (asteroids). The most striking feature is the close crowding and even overlapping of hundreds of craters, yet retaining perfect form. The absence of non-circular forms has been noted as an objection to the impact theory.

Two significant elements in the lunar landscape are the high topographic relief of the crater ridges and basins, and the clearness of the surface details, especially the irregularity and asperity of the circular ridges. If the infalling planetesimals were vaporized, then in the areas where the craters are closely crowded, the thick mantle of precipitated planetesimal substance would certainly bury the surface details and at least partly fill the basins. Only the younger craters would remain uncovered and distinct. This appears definitely to rule out the conception of vaporization of the infalling bodies. The crater forms with the depth of the basin suggest that the planetesimal produced a splash in the uncompacted lunite and, passing downward with its energy transformed to heat, was engulfed as a molten body in the lunite; a revulsion producing the central cone. The velocity of the impacting body is an undetermined critical factor. It is assumed that all the planetesimals were traveling

[2] The term meteor refers to the atmosphere. A body falling through the atmosphere we call a meteor. As the moon had no atmosphere it had no meteors. For its accretionary infalls we have no better name than planetesimals.

in the same general direction with the earth and moon, and were captured by the attraction of the planets in some sort of overtake and intake. The acceleration of the velocity of infall due to gravitation except on close approach was on the moon only one eightieth of that of the earth.

The remarkable central cones are quite certainly an effect of the recoil, revulsion or upthrow of liquid or semi-liquid from violent disturbance. In experimentation this feature results with burial or engulfment of the missile. The level smooth floors of the majority of craters suggest liquidity.

From this brief study it would appear certain that the planetesimals were not vaporized. Their stoppage was unlike that of the Meteor Crater bolide. They plunged deeply into the incoherent lunite before their energy was entirely changed to heat. Free explosion in the deep inclusion was inhibited, but fusion occurred, of both the planetesimal and the enclosing lunite. Under this conception all the moon's substance passed through a state of fusion. This would give the lunite the dark color and resemblance to terrestrial lava and scoria.

Lunar Plains

The larger part of the moon's surface is comparatively or entirely destitute of craters. These relatively smooth areas were called "seas" or "maria," under the mistaken conception that the moon once had atmosphere and ocean. The striking contrast between areas covered with craters and adjacent areas quite or wholly destitute of craters would seem on first thought to be fatal to the accretion theory. The volcanic conception did not explain this discrepancy.

It must be supposed that the infalling planetesimals were quite impartially distributed over the lunar surface. The present difference must be due, not to unequal infall but to destruction of the impact features. For this we may not invoke external or cosmic agency but must recognize some force or process within the moon itself. An evident internal force is gravitation with condensation and contraction process. With a radial depth of over 1,000 miles and the loose texture of the lunite, there must have been considerable subsidence of the lunar surface. The maria are such areas of depression below the general surface. The large irregular areas, comparatively destitute of perfect impact features, yet carry many remnants of broken-down crater rims. They probably are the areas of surface subsidence since the moon became of age. The structure and behavior of the porous and brittle lunite were so different from that of the earth's solid crust that the peculiar mechanics are difficult of interpretation. It appears that some factors have largely but not entirely shattered or broken down the crater topography. A few craters in good form on the wide plains are record of planetesimal infall subsequent to the areal subsidence.

Some of the borders of the plains are depressed alongside of mountain ridges, a relation similar to differential vertical movement or faulting on the earth. Such relations are the natural effect of local subsidence.

The large circular areas, "ringed plains," probably are the impact areas of great planetesimals. The great variation in size of the records of impact, from minute pittings up to the "Mare Imbrium" 700 miles in diameter, is the normal record of planetesimal infall.

The variety of singular forms and markings on the lunar surface, never explained under volcanism, will probably find explanation as the peculiar effects of planetesimal impact and explosion.

Stages in the cosmic history of the lunite: 1. Existence in the sun for a near-eternity of time, as superheated vapors of all known elements. 2. Removal from the sun with distribution far out in interstellar space, with subjection to absolute zero temperature. 3. Motion in orbital revolution around the parent body, with loss of heat and condensation to liquid state. 4. Continued cooling and condensation to solid state, as planetesimals of size from molecules to masses like the asteroids. 5. Collision with the moon, probably producing a second state of fusion. 6. Cooling and condensation to solid lunite. 7. The latter infall exposed to human vision through 240,000 miles of space and subjected to human cogitation.

The Juvenile Earth

The earth had its inception, perhaps it might be called its embryonic stage, as one of the larger masses of the planetesimal swarm. It grew by drawing to itself the other and smaller planetesimals that drifted within the range of its gravitational control, through the crossing of their orbits.

An important question at once arises as to the temperature of the infantile earth. It may be conceded as a possibility that the initial mass had high temperature. Such conception would imply that either the mass or knot of superheated material which served as the nucleus of the young earth had retained its heat from the far time of solar outpouring or that the accretionary process began promptly after the dynamic encounter. This might explain, in part, the supposed present very high temperature of the earth's interior. However, the length of time that must have been required for the young earth to gather in any great amount of material would have allowed the smaller planetesimals, traveling through a vacuum and absolute zero temperature, to lose their heat. But the much greater immensity of time required for the larger growth quite certainly implies cold accretion.

Whatever was the temperature of the infantile earth, the planetesimals that formed it must have been similar in composition or substance to those which later built the mature earth. They contained all the various elements which compose the earth and its envelopes. This rules out the fanciful idea that the earth's core is nickel-iron and that the globe is built of concentric layers of diverse composition. This conception of concentric structure appears to rest in the belief in an originally molten globe which was inherent in the discarded nebular hypothesis.

The temperature of the earth's interior in distribution and degree and perhaps in cause is yet undetermined. We do not know if the earth is gaining or is losing heat. To determine this, precise measurements are required through centuries of time. If we may assume that physicists in the far future will have scientific curiosity and intelligence, it would be a fine bit of altruism for living geophysicists to make and record precise temperatures in deep drillings, in areas and under conditions that may be exactly duplicated centuries hence.

The juvenile period in the earth's development endured until the earth, in its growth, had acquired gravitative force sufficient to hold an atmosphere and primitive ocean. This ability was probably attained when the earth was about the size of Mars or with one ninth of its present mass. During this early stage of planetary growth, the surface of the planet probably was similar to that of the moon. The absence of air and water on the moon has permitted preservation of its surface features through the untold eons of time since the latest planetesimal bombardment. Under the planetesimal view the earth's core, about 4,000 miles diameter, is the original planetesimal substance, minus a large portion of its occluded gases, with chemical recombination and molecular readjustment under the enormous compression of eight ninths of the earth's mass.

Growth of the Globe

As the larger earth grew in mass and gravitative power it had increasing grasp on the flying planetesimals. The accretion was accelerated as long as the planetesimal supply was abundant; but the later growth of the globe had decreasing rate of accretion.

During the long stage of rapid accretion the earth's surface was in a state of great disturbance. The infalling planetesimals produced great splashing of the water bodies and tremendous concussion on the land areas.

The stony planetesimals that fell on the land surfaces were only less promptly hydrated and dissolved than were those which fell in the seas. With the planetesimal accumulation there was mingled the modified materials, volcanic eruptives and aqueous sediments. In deep burial the mixed materials were subjected to pressure, to heat and molecular reorganization. Eventually at lesser depths in the completed globe, this earth stuff has been highly differentiated into metallic segregations and the varieties of lava. A striking product of differentiation is found in the enormous amount of crystalline quartz, represented in all the metal-bearing quartz veins, in all the sandstones and quartzose rock and in the sand beaches of all the sea and lake shores of the world.

Great activity and change within and on the earth did not cease with the completion of its volume. It has continued restless like a living organism. Its dynamics and phenomena challenge human intelligence, and interesting and important problems are yet subjects of study. The writer, in bygone years, discussed geologic problems under the planetesimal conception.[3] One of those problems now requires further consideration, with change.

Beginning of Life

If life was initiated through chemical and physical action from inorganic matter, under control of solar energy, the physical conditions in degree of heat and moisture requisite for life processes were fulfilled when the earth had acquired volume and depth of atmosphere sufficient to conserve the solar heat. The planet Mars, with a diameter of 4,215 miles, somewhat more than one half of the earth's diameter, has a thin atmosphere with some water, but it is doubtful if the surface temperature is sufficient for either initiation or development of life as we know it. Perhaps the suitable conditions existed on the earth when its diameter was 5,000 miles, and it had about one fourth of its present mass. However, an inhibiting factor must be recognized. While the earth was acquiring three fourths of its total mass the accretionary process probably was accelerated so that the surface was continually mantled with fresh accumulation. And whether the material was partly of large planetesimals producing great commotion, as noted above, or was largely of planetesimal dust and minute bodies, as Chamberlin suggested, the conditions were unfavorable for life development.

However, when the earth was nearly full size, the accretionary process was slow, and slowing, then the physical conditions certainly were favorable for life. That relatively short span of pregeologic time yet must have been sufficient for the evolution from primitive life-substance to the highly organized animal life represented in the oldest unaltered geologic deposits.

[3] H. L. Fairchild, *American Geologist*, 33: 94–116, 1904; Geol. Soc. Amer., *Bull.* 15: 243–266, 1904; SCIENCE, 64: 365–371, 1926.

The philosophic claim is made that a single life germ might hold all the potency and promise of the entire organic world. But why restrict the beginning of life to a single germ? And why restrict the organic synthesis to one occasion? No good reason appears for supposing that the combination of forces on the surface of the mature earth was ever essentially unlike the present, and the circumstances which produced the primordial life must have been constant. This implies the probably continuous creation of organic matter to the present time. The amoeba either has retained its simplicity through countless generations of organic evolution during a vast length of time or it is of recent creation.

SCIENTIFIC EVENTS

INTELLECTUAL FREEDOM

THE following manifesto signed by 1,284 scientific workers, of whom sixty-four were members of the National Academy of Sciences, and eighty-five college presidents and deans and directors of industrial laboratories and experiment stations, has been issued:

In an article entitled "The Pragmatic and Dogmatic Spirit in Physics," which appeared in the April 30 issue of *Nature* (with strong editorial disapproval), wide publicity is given to the official Nazi position on science and scientific research. In essence the article is an attack on all theoretical physics, and, by obvious implication, on scientific theory in general. It introduces the official racialism of the Nazis to divide physicists into good, *i.e.*, non-theoretical and "Aryan," and bad, *i.e.*, theoretical and Jewish. Similar notions have appeared in many popular magazines and scientific journals in Germany, in the addresses and writings of the Minister of Education, of university rectors and deans, of scientists and non-scientists. Apart from racial theories, furthermore, science and art are subject to ruthless political censorship. These ideas have found concrete expression in the dismissal and persecution of over 1,600 teachers and scientists (by the fall of 1936) from German universities and research institutes (and now Austria and Italy too), and in the restriction of higher education to students having the "proper" political and racial qualifications.

American scientists, trained in a tradition of intellectual freedom, hold fast to their conviction, that, in the words of the resolution adopted by the American Association for the Advancement of Science, "Science is wholly independent of national boundaries and races and creeds and can flourish only when there is peace and intellectual freedom." If science, to quote the A.A.A.S. resolution again, is to continue to advance and spread more abundantly its benefits to all mankind—and who can attack that goal?—then the man of science has a moral obligation to fulfill. He must educate the people against the acceptance of all false and unscientific doctrines which appear before them in the guise of science, regardless of their origin. Only in that way can he insure those conditions of peace and freedom which are essential for him and for the progress of all mankind.

It is in this light that we publicly condemn the Fascist position towards science. The racial theories which they advocate have been demolished time and again. We need only point to the work of Heinrich Hertz in physics, Fritz Haber and Richard Willstätter in chemistry, Ludwig Traube, Paul Ehrlich and August Wassermann in biology and medicine, all German Jews and all empirical scientists. The charge that theory leads to a crippling of experimental research is tantamount to a denial of the whole history of modern physics. From Copernicus and Kepler on, all the great figures in Western science have insisted, in deed or in word, upon the futility of experimental research divorced from theory.

We firmly believe that in the present historical epoch democracy alone can preserve intellectual freedom. Any attack upon freedom of thought in one sphere, even as non-political a sphere as theoretical physics, is in effect an attack on democracy itself. When men like James Franck, Albert Einstein or Thomas Mann may no longer continue their work, whether the reason is race, creed or belief, all mankind suffers the loss. They must be defended in their right to speak the truth as they understand it. If we American scientists wish to avoid a similar fate, if we wish to see the world continue to progress and prosper, we must bend our efforts to that end now.

THE ASSOCIATION OF SCIENTIFIC WORKERS

THE resolution of the American Association for the Advancement of Science (SCIENCE, February 4, 1938) and recent actions of the British Association bear witness to a widespread interest on the part of scientific workers in the increasingly critical development of social problems. Members of the staff of Harvard University, the Massachusetts Institute of Technology and other institutions in Boston and Cambridge, Mass., have formed an Association of Scientific Workers, having as its aims: (1) to bring scientific workers together to promote an understanding of the relationship between science and social problems, (2) to organize and express their opinions on the steps to be taken towards the solution of these problems, (3) to promote all possible action on the conclusions reached.

The contribution of scientific workers to world progress is to-day larger than ever before. Nevertheless, they are faced with economic and international developments which continually become more critical. As a group they have virtually no control over the applications of science, and are without the means of expressing their opinions as to how these developments should be met. The only expressions of opinion

which reach the public are those of a few individuals whose views are not necessarily representative and in some instances grossly misleading.

The methods and purposes of the association are stated as follows:

(1) To bring scientific workers together to promote an understanding of the relationship between science and social problems.

(2) To organize and express their opinions on the steps to be taken towards the solution of these problems.

(3) To promote all possible action on these conclusions.

These aims may be brought about:

(1) By holding meetings at which speakers will present various social problems and the attitude of scientists toward them.

(2) By organizing informal study groups to examine some of these problems more closely.

(3) By giving expression to the collective opinions of scientific workers, and by taking appropriate action either individually, jointly or through collaboration with existing organizations.

The association will conduct its first open meeting in Emerson Hall, Harvard University, on December 19, when President K. T. Compton, of the Massachusetts Institute of Technology, will speak on "The Social Implications of Science." The association is also sponsoring an informal discussion group on the state of science under various social régimes. It is hoped soon to affiliate with other similar groups in Philadelphia and elsewhere. Communications should be addressed to the Secretary of the Association of Scientific Workers, Harvard Biological Laboratories, Cambridge, Mass.

THE ANNUAL MEETING OF THE UNION OF AMERICAN BIOLOGICAL SOCIETIES

THE annual meeting of the Council of the Union of American Biological Societies will be held on Wednesday afternoon, December 28, at 4:00 P. M., in the Salon of the Jefferson Hotel, Richmond, Virginia.

During the past year the union has continued to support projects of broad interest as promotion of *Biological Abstracts* and the teaching of biological sciences. Beginning with volume 13 (1939) *Biological Abstracts* will abandon the emergency subsidy plan which enabled it to maintain publication during 1938. The new plan adopted by the Board of Trustees provides for the usual monthly issue, but in addition this issue will be broken up into five sections as announced earlier,[1] which sell for $4–$9 a section together with a complete index. Other details of the plans for 1939 will be discussed at this time.

The Union's Committee on Biological Science Teaching is under the chairmanship of Dr. Oscar Riddle and includes the following members: E. V. Cowdry, F. L. Fitzpatrick, H. B. Glass and B. C. Gruenberg. It has undertaken two projects, one of which is already well advanced and is worthy of record here. This project is concerned with the formation of a national association for that group of more than 20,000 who teach biological subjects in secondary schools, and to the establishment of a journal to serve their special needs. Following meetings of the National Education Association in New York City on July 1, 1938, a National Association of Biology Teachers was formally established at a meeting called and largely financed by the committee. Fifteen delegates selected by members in twelve states took part in this organization meeting and elected officers. The first issue of the association's new journal, *The American Biology Teacher,* appeared in October, 1938. The committee continues its efforts to form local (city, regional or state) units of this national association, and thus to extend the association membership to teachers in all the forty-eight states and to a majority of all teachers of secondary biology. The present membership of approximately 1,500 comes largely from fifteen states, though forty states are represented. During much of 1938 Professor D. F. Miller, of the Ohio State University, has served as committee representative in the active promotion of this work. A grant of funds ($10,000 during 3 years) from the Carnegie Foundation for the Advancement of Teaching provides necessary and substantial support for work undertaken by this committee.

The promotion of *Biological Abstracts* and the integration of teachers of biology in a national association are activities which are obviously of interest to all member societies of the union. All living things age, and consequently the phenomena of aging are likewise basic. In 1937 the union secured the cooperation of the National Research Council and with the aid of a generous grant from the Josiah Macy, Jr., Foundation arranged a conference on the biological and medical aspects of aging at Woods Hole on June 25 and 26. The constructive exchange of ideas between the biologists and medical men who attended this conference was of assistance in the preparation of a comprehensive report on aging financed by the Macy Foundation, which will be published about January 1.

Privately endowed and operated biological institutions are at an increasing disadvantage compared with city, state and federal organizations. It has been suggested that a very important problem for the union it to formulate ways and means whereby the Federal Government may come to their support.

The union is eager to serve the member societies in any matters which are of interest to them collectively

[1] SCIENCE, 88: 294, 1938.

or individually. Consequently the secretary of the union will welcome suggestions from individuals as well as from officers of its member societies as to matters which could profitably be discussed at the next meeting which, as heretofore, will be open to all interested persons, even though they may not be official representatives of the member societies. It is hoped that all member societies will be represented by official delegates.

GEORGE W. HUNTER, III,
Secretary

GEOPHYSICS AS APPLIED TO CONTINENTAL STRUCTURE

ON December 27, at the meetings of the American Association for the Advancement of Science, a symposium on "The Importance of Geophysics to the Study of Continental Borders" will be presented by the American Geophysical Union before the astronomers of Section D and the geologists and geographers of Section E—this symposium having been arranged by the A. G. U. Special Committee on the Geophysical and Geological Study of Continents at the request of Section E. The purpose of this symposium will be both to define the functional relationship of geology and of geophysics in the determination of structural and dynamic conditions within the invisible portions of the earth's crust; and to illustrate how enormously the opportunities for the advancement of structural geology have been increased by geophysical research methods and appliances now existing.

Chester R. Longwell, of Yale University, will introduce the series of papers in a discussion of the relative roles of geology and geophysics in modern studies of the earth's crustal structure. Lieutenant Paul A. Smith, of the U. S. Coast and Geodetic Survey, will describe the nature and precision of the sounding methods, whereby submarine canyons have been traced along a part of the Atlantic margin of North America by Dr. A. C. Veatch and himself, under a project grant from the Geological Society of America. The geologic fate of the old continent or subcontinent of Appalachia will next be discussed by Wilbur A. Nelson, of the University of Virginia, after which Maurice Ewing, of Lehigh University, will describe the methods whereby the ocean-ward slope and depth of submergence of this old land area are being discovered. The delineation of deep-seated structural features of the earth's crust in continental border belts will then be the topic of papers by C. H. Swick, of the Coast and Geodetic Survey; G. P. Woollard, of Princeton, N. J.; and Perry Byerly, of the University of California. Mr. Swick will mention the modern methods used for gravity measurements, and will describe the recent programs of gravity observation in which the Coast and Geodetic Survey has been collaborating. Dr. Woollard will describe how geologic analyses of this evidence have shown that the visible structural features of the Appalachian Mountains are paralleled by invisible (but equally great) linear structural features, deep within the crust underlying the Piedmont and Atlantic Coastal Plain regions. And Dr. Byerly will show how seismic information can be used to determine the nature and dynamic condition of some of these deep-seated structural features of coastal areas. H. T. Stetson, of the Massachusetts Institute of Technology, will next discuss how the roles of extra-terrestrial forces in inducing crustal deformation may be tested, and how certain structural problems may possibly be solved by collaborative, astronomic-geophysical-geological studies, involving the use of the crystal chronometer and of other devices for the exact determination of time and of geodetic position. W. T. Thom, Jr., of Princeton University, will conclude the symposium by summarizing the results thus far achieved through geophysical research, as well as the opportunity (and need) for further collaborative study of continental borders—which are the thresholds to the "great unknowns" of the sub-oceanic lithosphere. A discussion period will follow the last paper.

The symposium, which will begin at 2 P.M. in the Mosque, will be preceded by a morning program on the "Geology of the Coastal Plain and Continental Shelf." The twenty-four contributors taking part in these two sessions will give a searching and comprehensive review of problems which are currently under active investigation along the eastern seaboard.

H. A. MEYERHOFF, *Secretary, Section E*
H. T. STETSON, *Secretary, Section D*
J. A. FLEMING, *Secretary, American Geophysical Union*

RECENT DEATHS AND MEMORIALS

DR. CHARLES E. MUNROE, emeritus professor of chemistry at the George Washington University, died on December 7 at the age of eighty-nine years.

DR. JAMES PIERPONT, since 1898 until his retirement with the title emeritus in 1933 Erastus L. De Forest professor of mathematics at Yale University, died on December 9 at the age of seventy-two years.

DR. DANIEL L. WALLACE, from 1920 to 1931 professor of chemistry at the University of Pennsylvania, with which he had been associated for fifty-one years, died on December 5 at the age of seventy-eight years.

ELLEN LOUISA BURRELL, head of the department of pure mathematics at Wellesley College, who retired in 1916, died on December 3 at the age of eighty-eight years.

DR. HERBERT U. WILLIAMS, who retired in 1915 as

dean of the Medical School of the University of Buffalo, died on December 8 at the age of seventy-two years. Dr. Williams was appointed professor of pathology and bacteriology at the Medical School in 1894 and was a member of the faculty for forty years, retiring in 1934.

DR. JOHN DOUGLAS, clinical professor of surgery at New York University, consulting surgeon, died on December 5 in his sixty-fourth year.

DR. PORTER W. SHIMER, consulting chemist, president of the Shimer Chemical Company, died on December 6 at the age of eighty-one years.

THE division of botany of the University of California at Davis held on November 30 a special seminar commemorating the one hundredth anniversary of Schleiden and Schwann's formulation of their cell theory. Dr. T. I. Storer briefly reviewed their work and the investigations of other men which led up to the cellular concept. The importance of the cell theory in present-day studies of bacteriology, physiology, genetics and plant pathology was discussed by Drs. C. S. Mudge, Max Kleiber, F. N. Briggs and W. B. Hewitt. The publications of many pioneer cytologists were on exhibit. Microscopic demonstrations illustrating important discoveries and plants and animals used by various cytologists were arranged by members of the departments of botany and zoology.

SCIENTIFIC NOTES AND NEWS

THE Gold Medal of Achievement for 1938 of the Poor Richard Club of Philadelphia has been awarded to Dr. David Sarnoff, president of the Radio Corporation of America and chairman of the board of the National Broadcasting Company. The medal will be presented to Dr. Sarnoff at the annual banquet to be given on January 17, the birthday of Benjamin Franklin. The award is made annually to a person whose accomplishments "have materially helped advance American civilization and raised the standards of living of Americans."

THE Penrose Medal of the Society of Economic Geologists has been awarded to Reno H. Sales, chief geologist of the Anaconda Copper Mining Company. The presentation will be made at the annual dinner of the society to be held on February 14 at the Harvard Club, New York City.

AT the New York meeting on December 6 of the American Society of Mechanical Engineers the Holley Medal for "meritorious services in the development of the steam turbine" was presented to Francis Hodgkinson, honorary professor of mechanical engineering at Columbia University and formerly an associate of George Westinghouse. The Holley Medal previously has been awarded to the following men: 1924, Hjalnar Gotfreid Carlson; 1927, Elmer Ambrose Sperry; 1929, Baron Chuzaburo Shiba, of Japan; 1934, Irving Langmuir; 1936, Henry Ford; 1937, Frederick G. Cottrell. Lawford H. Fry, of Pittsburgh, received the Worcester Reed Warner Medal for written contributions to improved locomotive design and to the utilization of better materials in railway equipment. Alphonse I. Lipetz, of the American Locomotive Company at Schenectady, received the Melville Medal for a paper entitled "Thin Air Resistance of Railroad Equipment"; Wilfred E. Johnson, of Fort Wayne, received the Pi Tau Sigma Medal, and Arthur C. Stern, of New York City, received the Junior Award of the society.

DR. ELLIOTT C. CUTLER, Moseley professor of surgery at Harvard University and chief surgeon at the Peter Bent Brigham Hospital, Boston, was awarded on November 22 an honorary doctorate by the University of Strasbourg, France.

DR. CARL J. WIGGERS was honored by his associates at a surprise tea on the afternoon of November 23 to celebrate the twentieth anniversary of his appointment as professor of physiology at Western Reserve University School of Medicine. On this occasion Dr. Wiggers was presented with a book of photographs and letters of appreciation from the president of the university, the dean of the School of Medicine, members and former members of the staff of the department of physiology and students who had worked under him.

DR. J. EDMUND WOODMAN, professor emeritus of geology in the New York University College of Engineering, was the guest of honor at a dinner given on December 10 by his former graduate students at the Faculty Club in recognition of his twenty-nine years of service on the faculty. Dr. Woodman was head of the department of geology from 1927 until his retirement this autumn.

THE Student Branch of the American Institute of Chemical Engineers at the Ohio State University entertained Dr. Edgar C. Bain, assistant to the vice-president in charge of research of the U. S. Steel Corporation, New York City, at a dinner meeting on November 18. The dinner was attended by seventy-five members of the student branch and officers of the Central Ohio Section of the American Society of Metals and the national secretary, W. H. Eisemann. Following the dinner, Dr. Bain made an address on the theoretical and practical problems of modern steel development from a metallurgical point of view. The new colored motion picture of steel manufacture by the U. S. Steel Corporation was exhibited.

ALEXANDER G. CHRISTIE, professor of mechanical engineering at the Johns Hopkins University, was inducted into office as president of the American Society of Mechanical Engineers at the fifty-ninth annual meeting held in New York City. The ceremony of induction, held in the presence of the society's council, consisted in the formal transfer of the gavel by the retiring president, Dr. Harvey N. Davis, president of Stevens Institute of Technology, and a short inaugural statement by Professor Christie.

OFFICERS of the American Pharmaceutical Association have been elected as follows: *President-elect,* Dr. A. G. DuMez, Baltimore; *First Vice-president,* F. O. Taylor, Detroit; *Second Vice-president,* F. J. Cermak, Cleveland; *Members of the Council,* H. C. Christensen, Chicago, Ill.; R. P. Fischelis, Trenton; Ernest Little, Newark. These officers will be installed at the next annual meeting of the association, which will be held in Atlanta, Ga., the time to be announced later.

DR. CLYDE L. CUMMER, assistant clinical professor of dermatology and syphilology at the School of Medicine of Western Reserve University, was reelected director and treasurer at the St. Louis meeting of the American Academy of Dermatology and Syphilology.

THE title of professor emeritus of chemistry has been conferred by the University of London on Dr. Samuel Smiles on his retirement from the Daniell chair of chemistry at King's College.

DR. TIFFENEAU, professor of pharmacology and materia medica, has been elected dean of the Faculty of Medicine of the University of Paris.

DR. D. R. PORTER, associate professor of truck crops at the College of Agriculture at Davis of the University of California, will conduct research for the Campbell Soup Company with headquarters in New Jersey. He will be concerned with vegetable breeding for quality and disease resistance.

WILLIAM B. COLEMAN, consulting chemist and metallurgist of Philadelphia, has been appointed a member of the membership committee of the Franklin Institute.

DR. JOHN WENDELL BAILEY, professor of biology at the University of Richmond, Va., is on leave for the current academic year. He is serving as director of biological research for the Chesapeake Corporation, manufacturers of kraft paper, at West Point, Va. Dr. Carl W. Hagquist, of Brown University, is teaching Professor Bailey's classes in zoology.

DR. ARTHUR B. CLEAVES has been granted leave of absence from the Pennsylvania Topographic and Geologic Survey to accept an appointment as geologist for the Pennsylvania Turnpike Commission, which is engaged in building the new "super highway" across southwestern Pennsylvania.

DR. PHILIP A. MUNZ, professor of botany at Pomona College at Claremont, Calif., sailed on December 2 from New Orleans to spend several months studying the evening primrose in South America.

AT the annual meeting of the trustees of the Josiah Macy, Jr., Foundation, held on December 6, two new members of the board were elected: Dr. Stanhope Bayne-Jones, dean of the Yale School of Medicine, and Dr. Charles Sidney Burwell, dean of the Harvard Medical School. Other members of the board are: Robert E. Allen, Dr. John Dewey, Dr. Harry Emerson Fosdick, William W. Hoppin, Dr. Ludwig Kast, Dave Hennen Morris, Lawrence Morris, Dr. Willard C. Rappleye, Dean Sage, Paul H. Smart, Edwin S. S. Sunderland, Dr. Samuel Trexler and J. Macy Willets. The following officers were reelected: The Hon. Dave Hennen Morris, *chairman;* Dr. Ludwig Kast, *president;* J. Macy Willets, *secretary;* Robert E. Allen, *treasurer.* Lawrence K. Frank, formerly assistant to the president, was appointed vice-president. At this meeting it was announced that Mrs. Walter G. Ladd, who established the foundation in 1930 in memory of her father, had made a substantial gift in further support of the work of the foundation. During the present year the foundation has made grants aggregating $175,420 to thirty institutions in the United States and in Europe, in support of medical research.

AN Empire Rheumatism Council Research Foundation, to work in cooperation with the Admiralty to investigate the causes and the best means of prevention and treatment of rheumatic disease in the training establishments of the Royal Navy, has been established in Great Britain. The Research Advisory Committee has appointed a special *ad hoc* subcommittee, consisting of Lord Horder, Sir William Willcox, Professor Geoffrey Hadfield, Dr. Mervyn Gordon and Dr. W. S. C. Copeman, to supervise the work generally. Dr. C. A. Green, of the department of bacteriology of the University of Edinburgh, will take direct charge of the foundation. The Sir Halley Stewart Trust has granted him a research fellowship for three years for this task. He will be assisted by other permanent workers as and when found necessary. Every factor in the problem—bacteriological, biochemical and environmental—will be investigated at the chief naval training establishments.

DR. REGINALD A. DALY, Sturgis-Hooper professor of geology at Harvard University, lectured in the department of geology at the Ohio State University on the afternoons of December 1 and 2 and before the Society of Sigma Xi at the Ohio State University on

the evening of December 1. The subjects of the lectures were "New Facts in Physical Geology," "The Problem of Isostasy" and "Deep-sea Canyons."

DR. SAM F. TRELEASE, professor of botany at Columbia University, gave an address entitled "Selenium Poisoning on the Great Plains" on December 14 at the university before the Kappa chapter of Sigma Xi.

DR. SAMUEL H. WILLIAMS, professor of biology at the University of Pittsburgh, will deliver the annual lecture of the chapter of Sigma Xi of the University of Maryland on January 11. Dr. Williams, who spent the summer in Haiti, will speak on "Some Aspects of Tropical Research."

PROFESSOR F. LONDON, of Duke University, lectured at an open meeting of the Purdue University Chapter of Sigma Pi Sigma, the physics honorary society, on November 28, on "The State of Liquid Helium near Absolute Zero."

DR. WILLIAM BOYD, professor of pathology and bacteriology in the University of Toronto, gave a Mayo Foundation lecture on December 1 at the Mayo Institute. His subject was "Some Reasons for the Recent Increase in Bronchial Carcinoma."

THE twenty-third Guthrie Lecture was given before the British Physical Society by Dr. A. V. Hill, Fullerton research professor of the Royal Society, on November 11 at the Imperial College, London. The subject of the lecture was "The Transformations of Energy and the Mechanical Work of Muscles."

DR. J. B. S. HALDANE, professor of genetics at University College, London, delivered the Lloyd Roberts Lecture on "Some Problems of Human Congenital Disease" at the Royal College of Physicians of London on November 17.

A NEW hall for the exhibition of Dinosaurs was opened at the Academy of Natural Sciences, Philadelphia, on November 17. It was designed and arranged by a committee of which Rodolphe M. deSchauensee was chairman. Harold T. Green supervised the technical installation and Dr. Benjamin F. Howell, curator of geology and paleontology, was scientific adviser. The opening of the hall was preceded by an illustrated lecture given by Bradford Washburn, of the Harvard School of Geographical Exploration.

THE Rose Memorial Observatory at the Nebraska Wesleyan University, which was dedicated in the spring, is a brick and concrete structure housing a six-inch equatorially-mounted refractor in the dome, with an additional room for the meridian transit instrument, clocks and chronograph. A basement room is provided, in which it is planned later to install seismographic equipment. The building is the gift of alumni and friends in honor of the late Charles Dunham Rose, who served the institution for thirty-seven years as professor of mathematics and astronomy.

AN Industrial Fellowship in Air Filter Research has been established at the Mellon Institute, Pittsburgh, Pa., by the American Air Filter Company, Inc., of Louisville, Ky. This fellowship will investigate broadly materials of value in the construction of filters for air-conditioning systems and will have the direct cooperation of specialists on the staff of the multiple industrial fellowship on air hygiene in operation in the institute. Dr. Frank F. Rupert, who has been appointed to the fellowship, has been a member of the institute since 1913 and has been associated with the fellowship in air hygiene for the past three years.

DR. E. PORTER FELT, director of the Bartlett Tree Research Laboratories, Stamford, Conn., has presented a plaque to the Massachusetts State College at Amherst, to be affixed to the present mathematics building, marking that building as the original home of economic entomology at the college.

THE first number of the *Science Observer,* a new publication addressed primarily to the school children of the nation, has been issued. The publication is part of the program of junior activities of the American Institute of the City of New York, with the aim of encouraging the interest of high-school students in science. Although issued as the official newspaper of the Science and Engineering Clubs sponsored by the American Institute, the *Observer* is expected to have a wide appeal among adults. The publication is an eight-page newspaper, tabloid size, containing four pages of news of science and club work and four pages of photographs.

Science Notes, published by the College of Natural Science, Yenching University, Peiping, China, states that the fourth annual report on the Ceramics Project has been published, reviewing the work carried out during the past year under the British Boxer Indemnity grant for ceramics research. The work includes studies on base exchange in clays, glaze suspensions and the experimental production of ceramic ware on a semi-commercial scale. This project is under the direction of Dr. E. O. Wilson. The report is issued in both English and Chinese. A chemical study of methods of composting as applied to the raw materials available in North China, subsidized by the Rockefeller Foundation, is entering upon its third year. The work with experimental stacks at Cheeloo University was suspended last year, but arrangements

are now being made to continue it. The chemical work is under the direction of Dr. S. D. Wilson and the biological and parasitological phases are being conducted by Dr. G. F. Winfield, of Cheeloo University.

AT the University of Oxford a statute has been promulgated amending the provisions of the statutes governing the study of forestry. The object of the proposed statute is to simplify and to render more coherent the organization of the study of forestry by merging the School of Forestry and the Imperial Forestry Institute under a single control, and thereby to enable the university to make a more valuable contribution to forestry work throughout the empire. Under the new statute the department of forestry will be under the direction of the professor of forestry, and one central committee will provide for the instruction and supervision of four classes of students. These will be (*a*) forest service probationers; (*b*) forest officers taking refresher courses; (*c*) undergraduates who have taken honors in honor moderations in natural science and graduates or undergraduates who have taken honors in a final honor school; and (*d*) candidates working for the diploma in forestry. This same committee will also provide for the higher training of forest officers and for the conduct of research into the formation, tending and protection of forests.

THE boundary of Hawaii National Park, Hawaii, has been authorized to be extended eighty-six square miles, as the result of an act at the last session of Congress. Besides authorizing the addition of lands in the so-called Kalapana and Footprint area to the park, the act also authorizes the acquisition of additional lands adjacent or contiguous to the existing park for the purpose of rounding out its boundaries. The act permits the United States to accept title by donation or gift, but prohibits the expenditure of Federal money for the purchase of land. Included in the 86 square miles of land authorized to be made part of the park are 12 miles of ocean shore line and areas of historic, archeological and scenic interest. Hawaii National Park was created in order to preserve the volcanic exhibit existing on the twelve islands that comprise the Hawaiian group.

DISCUSSION

WHAT IS SOIL?

RECENT references to the culture of plants in sand, cinders or gravel to which solutions of nutrient salts are added as "soilless crop production" have caused confusion as to the differences between hydroponics and non-hydroponic culture. This raises the question, "What is soil?" While soil scientists are not agreed as to all the physical, chemical and biological characteristics of the earth's surface that are to be included in the term, nevertheless they and the farmers are agreed that soil is ground or foundation in and on which plants grow if water and plant food are available. This foundation is a more or less porous solid that holds water as thin films around various-sized particles. This distinguishes soil, ground or foundation from that part of the earth's surface in which water is not so held. Thus to use the term "soilless" in any connection that ignores this fundamental difference between porous solids and liquids has no justification.

To contend that when sand, cinders or gravel have been treated and all plant nutrients removed they are therefore "soilless" and that the subsequent additions of nutrients thereto still retain these materials in such state ignores basic differences of properties that must be considered in classification. One would not contend, that when the soil solution of a fertile field has become virtually depleted of available nutrients by the growing of a crop, consequently could not sustain another crop until nutrients have been restored by whatever way this may be accomplished, the nutrient-depleted field is in a "soilless" state. The presence or absence of one or all nutrients held in solution or otherwise in a porous solid does not differentiate categorically between the soil and soilless state of culture media.

The quantity of nutrients in a culture medium reflects fertility or crop-producing potentiality. However, as other conditions are essential to growth of crops, therefore fertility of any culture medium must be considered in a relative sense whenever comparison is made. The insoluble particles of soil are not involved in its fertility. This is a function of the character of the soil solution. The insoluble character of a part of the soil certainly is not a basis for defining such material as "soilless." Insoluble material is an essential part of soil.

Soil is a means of providing vegetation with nutrients and as long as they are incorporated therein are part of the soil. The elimination of available nutrients therefrom, however, does not alter the basic physical and geologic character of the earth's crust described as soil. But soils are not studied as a geophysical science. Soils have a biologic meaning. It is the relation of the earth's crust to vegetation that determines the scope of the concept implied in the term.

The basic difference beween the soil and soilless types of culture media is in the mobility of the solutions they hold and retain. In the one case the solution

is held as surface film, in the other, which contains no solid particles, the liquid manifests full hydrostatic properties.

Cinders and gravel, which can not provide the properties required of soilless culture media, are large-sized particles, hence their water-holding capacity is low. The pores are of good size, hence drainage is rapid. Frequent application of nutrient solution is necessary, which is usually obtained by flooding the beds in which the plants are set. For convenience and economy the drained solution is used over and over. Basins are necessary to hold these low water-retaining materials so as to check the too rapid drainage of the frequently added nutrient solution. But the imperative need for drainage to open the pore spaces to air necessary for growth of crops in this type of culture media emphasizes the soil characteristics of the material. The removal of the excess solution completes the picture of the true characters of a soil—water held as films by solid particles, also some water held in the free state and its flow retarded by friction, with air space between the particles arising from drainage, following saturation by rain or irrigation.

Another basic difference between the soil and the soilless types of culture media is in the amounts of water and nutrients a given volume of each provides vegetation and in the consequent effect thereof in the magnitude of production. A unit volume of culture media that contains no solids provides more water and nutrients than does one in which space is occupied by solids. In these premises are found the explanations for the markedly greater productive potentiality of hydroponics, which is obviously soilless, than that of agriculture. Those who contend that if ample amounts of nutrients were supplied to a good soil the productive potentiality per unit area thereof would equal that of hydroponics have failed to provide evidence. Because hydroponics permits denser stands of vegetation than is possible with soils, therefore larger yields are obtained. For example, a basin—1/220 acre—carrying three crops at once for part of their growth periods, the stand of each denser than that of agriculture, yielded 8.6 bushels (60 pounds per bushel) of potatoes, more than 1,000 pounds of tomatoes and celery not yet matured. Another basin of the same size planted to potatoes and corn yielded 6.8 bushels of potatoes, and although the corn is not yet mature for harvest, nevertheless the indicated yield predicts production far in excess of that known to agriculture. Experimental evidence is also at hand showing that two crops of potatoes can be so grown as to be harvested together with yield markedly exceeding the above-mentioned large yield of a single crop. The second crop is planted at such a growth stage of the first crop that when the latter has passed the period of full light requirement the former enters therein. Also evidence is at hand that the two and three crops grown together as mentioned do not constitute the full productive potentiality of hydroponics in regions having long seasons of favorable climate.

Terminology of languages does not convey the same meaning and distinctions. "Soil" in English has a synonym, "dirt—something that pollutes, such as loose earth, dust, muck, manure." These, however, are materials that enrich land—that is, build soil. The absence of these in land could in a sense be construed to mean soilless. But is it becoming to the dignity of land to call dirtless soil "soilless"? In other languages, the concept of ground and foundation has not been taken away in the terminology commonly applied to the earth's crust which supports vegetation. Earth materials like sand or gravel, if used for the culture of plants, are not classed as "soilless."

W. F. GERICKE

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ARE THERE DIFFERENT CRITICAL OXYGEN CONCENTRATIONS FOR THE DIFFERENT PHASES OF ROOT ACTIVITY?

RECENT investigations with apple tree roots under field and greenhouse conditions have indicated that there may be different critical oxygen concentrations for different phases of root activity.

(1) *Subsistence.* Evidence from field studies now in progress indicates that apple tree roots larger than 1 mm in diameter are able to subsist in soil atmospheres containing less than 0.1 per cent. to 3.0 per cent. oxygen for considerable periods of time when the tree as a whole is in active growth. Controlled greenhouse experiments with apple seedlings[1] point to the probability that when the oxygen in the soil atmosphere is maintained at 3 per cent., the roots are at a "subsistence level" with respect to oxygen, that is, they continue to live but grow slowly if at all. At oxygen pressures below 1 per cent. they seem actually to lose weight. This "subsistence level" probably coincides with the lower critical concentration as defined by Cannon.[2]

(2) *Initiation of new roots.* Recently Tukey and Brase[3] have found that during wet years newly planted apple trees have produced larger root systems and tops when German granulated peat moss has been incorporated with the soil in the tree hole than when topsoil alone was used. During dry years there was little or no beneficial effect from the peat. Through the cour-

[1] J. DeVilliers. Unpublished data.

[2] William Austin Cannon, *Carnegie Inst. Wash. Pub.* 368, 1925.

[3] H. B. Tukey and K. D. Brase, *N. Y. State (Geneva) Agr. Exp. Sta. Bull.* 682, 1938.

tesy of Dr. H. B. Tukey, analyses of soil gases in boxes containing newly planted apple trees, kept under controlled conditions, were made by the authors at the Geneva Agricultural Experiment Station, and present a possible explanation of this situation—namely, that a high oxygen level may be necessary for initiation of new roots from an existing root system. In this case, a soil atmosphere containing about 12 per cent. oxygen appeared to reduce the size of the root systems and tops considerably.

(3) *Growth of existing root tips.* Normal growth of existing root tips occurs at the upper critical concentration of oxygen, as defined by Cannon. The greenhouse study with apple seedlings indicates that normal growth does not occur at oxygen concentrations below 10 per cent., even though there may be considerable growth at percentages between 5 per cent. and 10 per cent.

(4) *Absorption and accumulation.* The experiments of Hoagland and Broyer[4] have emphasized the dependence of the processes resulting in absorption and accumulation on aeration. In this connection it is noted that the ash content (as percentage dry weight) of apple seedlings grown at different oxygen pressures decreased uniformly as the oxygen percentage was decreased below 15 per cent. Since the dry weight of the root tissue was less at oxygen percentages below 10 per cent., it is probable that absorption and accumulation were inhibited at oxygen pressures below 10 per cent. This happens to coincide with the apparent upper critical concentration and may mean that maximum accumulation occurs at the upper critical concentration of oxygen.

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A PECULIARITY OF PIGMENTATION OF THE UPPER ARM OF NEGROES

DURING the routine examination of Negroes in the Johns Hopkins Hospital, Baltimore, Maryland, we have recently observed a peculiarity of pigmentation common to a significant proportion of the patients. At a point on the antero-lateral surface of the upper arm the darker color of the outer aspect of the extremity abuts on the less heavily pigmented flexor surface. In the subjects referred to, this change is not a gradual fading of the dark pigment as the eye passes medianward over the flexor surface, but the transition is an abrupt one, producing a very definite linear appearance. Usually this margin between the darker dorso-lateral and the lighter antero-median surfaces begins to be obvious a little below the greater tubercle of the humerus and follows the lateral edge of the belly of the biceps muscle distally, disappearing again just below the middle of the humerus; it averages about ten centimeters in length. The line tends to parallel and superimpose itself over the course of the cephalic vein; however, it bears no constant relation to this vessel, its course lying lateral to that of the vein in one subject and medial to it in another. The mark is usually bilateral and more or less symmetrical in the two arms, but is occasionally present on one arm and absent on the other.

A total of two hundred Negroes of both sexes, aged eleven to seventy-four years, in the hospital wards for adult patients, were examined for the presence of the line. It was sharp and distinct bilaterally in thirty-five patients, or 17.5 per cent.; in another 2 per cent., it was present unilaterally. The incidence was the same in both sexes and at all ages. The occurrence of the line was relatively as frequent in light-skinned as in dark-skinned Negroes; it has been seen in young children. In emaciated subjects with relaxation of the skin the line was usually more striking than in well-nourished patients; this was to be expected. In a colored male Jamaican the line was particularly marked and could be followed upward to the point of the shoulder bilaterally, higher than usual. This latter subject volunteered that his father had the same mark. However, there were encountered no other patients who had noted the phenomenon in relatives; the very few who had been aware of its presence on their own persons stated that it had been there as long as they could remember. Biopsy of the skin of one Negro was taken across the line; microscopically there could be observed no variation between the two sides of the line either in morphology or in the amount of pigment in the epidermis. No similar line has been encountered on the inner side of the arm, the trunk or the lower extremities of a Negro or anywhere on the body of a white subject.

Probably this observation has been made before, but we have been unable to find any reference to it. Texts such as Cockayne's "Inherited Abnormalities of the Skin and Its Appendages"[1] one would not expect to discuss apparently so common and insignificant a variation as the one under consideration. Dr. Adolf Schultz, of the Department of Anatomy of the Johns Hopkins Medical School, when consulted on the subject, stated that it is a well-known anthropological tenet that in general the dorsal and extensor surfaces of the body are somewhat more heavily pigmented than the ventral and flexor areas. It is the abruptness of

[4] D. R. Hoagland and T. C. Broyer, *Plant Phys.*, 11: 471–507, 1936.

[1] E. A. Cockayne, "Inherited Abnormalities of the Skin and Its Appendages." London, Oxford University Press, 1933.

this transition in the upper extremities of some Negroes which we wish to emphasize in this note.

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ADDITIONAL RECORDS OF HIPPOBOSCIDAE FROM MOURNING DOVES

COATNEY[1] has reported on two species of Hippoboscidae from the Eastern mourning dove (*Zenaidura macroura carolinensis*). These are *Stilbometopa podopostyla* Speiser and *Ornithoica confluenta* Say.

The writer has taken an additional species, *Microlynchia pusilla* (Speiser), in southwestern Texas. From September 2 to September 12, 1936, two or three dozen doves were killed in Bexar County in the vicinity of San Antonio. Almost without exception each bird was infested with this hippoboscid, as many as ten flies being taken from one individual. *Stilbometopa podopostyla* was taken frequently, but not so abundantly as *M. pusilla*. In a few cases both species were found on the same dove.

Determinations were made by Dr. J. Bequaert, of the Harvard University Medical School.

Microlynchia pusilla, determined by Dr. Alan Stone, of the Division of Insects Identification of the Bureau of Entomology and Plant Quarantine, also was taken from a dove near Uvalde, Texas, on October 21, 1936, by W. L. Barrett and R. W. Burgess, of this bureau.

JAMES M. BRENNAN

DIVISION OF INSECTS AFFECTING MAN
AND ANIMALS, BUREAU OF ENTOMOLOGY
AND PLANT QUARANTINE, U. S. DEPARTMENT
OF AGRICULTURE

THE TEACHING OF BOTANY IN AMERICAN COLLEGES AND UNIVERSITIES

THE Committee of the Botanical Society of America on the Teaching of Botany wishes to express its appreciation to the 264 departments of botany that have cooperated in this study. The published report summarizes the objectives, content and procedures in the teaching of the general botany courses in these departments, and adds brief discussions concerning these. It has been mailed to all cooperating departments and to all members of the Botanical Society of America. A limited number of copies of the report is available to others interested; four cents postage should accompany requests.

An additional bulletin on the construction of tests for the measurement of student achievement will be published by the end of the year.

E. L. STOVER

CHARLESTON, ILL.

SOCIETIES AND MEETINGS

THE INTERNATIONAL CONGRESS OF MATHEMATICIANS

DURING the week beginning on September 4, 1940, the International Congress of Mathematics will hold a meeting in Cambridge, Mass.

The forerunner of the International Congress of Mathematicians was a meeting held at Chicago in 1893, in connection with the World's Columbian Exposition. The officers were: W. E. Storey, president; E. H. Moore, vice-president, and H. W. Tyler, secretary. Forty-five papers were read by mathematicians from seven different countries. The principal long addresses, later published by the American Mathematical Society, were delivered by Felix Klein, imperial commissioner from Germany.

The first congress in Europe was held at Zurich in 1897. Since that time, except for the interruptions caused by the world war, sessions have been held about once every four years. The only one of these in North America was the congress of 1924 at the University of Toronto. Here hospitality on a generous scale was made possible by subventions from the Dominion of Canada and the Province of Ontario.

The most recent congress was held in Oslo in 1936. At that meeting the invitation of the American Mathematical Society for 1940 was accepted.

The numbers in attendance have steadily increased, averaging about 600 at recent congresses. Some 250 short papers have been presented by representatives of about 40 different countries.

The dates of the forthcoming congress have been fixed as September 4 to 12, 1940. The American Mathematical Society will not hold its usual summer meeting in that year. Harvard University and the Massachusetts Institute of Technology will be the principal local hosts. Some neighboring institutions will join in the hospitality, but all the institutions of the United States and Canada are invited to consider themselves as participants. Mathematicians so desiring will be housed in the Harvard University dormitories at modest rates, and meals will be served at cost in the university dining rooms. There will be accommodations for members of families, with special provision for the care of children. Those visitors who prefer hotel accommodations can be comfortably provided for in Cambridge or Boston. The society will be able to provide room and board without charge to a considerable number of foreign guests during the week of the congress. In connection with the Harvard Tercentenary in 1936 the American Mathematical Society and the Mathematical Association of America held a highly successful meeting in Cambridge, attended by some eight hundred persons, and there is every reason to expect equally satisfactory arrangements for the 1940 congress.

[1] Coatney, SCIENCE, n.s., 88: 2281, 258, 1938.

Following precedent, there will be a score of invited addresses, each of an hour's length, and sectional meetings for the presentation of short papers.

An innovation will be four conferences, something after the pattern of recent international gatherings in Moscow for topology and in Zurich for probability. There will be a conference on algebra, with Professor A. A. Albert as chairman, one on probability, the theory of measure and allied topics, with Professor Norbert Wiener as chairman, one on topology, with Professor Solomon Lefschetz as chairman and one on mathematical logic, with Professor H. B. Curry as chairman. These conferences will give an opportunity for specialists to exchange information and opinion among themselves, and also to disseminate new and important results to the mathematical public at large. The program will include formal lectures and informal open discussion.

The short papers will be presented in six sections:

I. Algebra and Number Theory.
II. Analysis.
III. Geometry and Topology.
IV. Probability, Statistics, Actuarial Science, Economics.
V. Mathematical Physics and Applied Mathematics.
VI. Mathematical Logic and Philosophy.

A session on history and didactics will be held in connection with the congress, with the cooperation of the Mathematical Society of America.

The short papers will preferably be in one of the official languages of the congress: English, French, German or Italian, and in general will not exceed ten minutes in length.

Among the entertainment features provided will be a reception, a garden party, a symphony concert and a banquet. Several excursions will be planned, and it is hoped that many American mathematicians who have automobiles with them will cooperate with the entertainment committee in arranging additional trips for the foreign visitors to be made out of Cambridge.

Effort will be made to facilitate the travel at reasonable cost of foreigners while they are in the United States. Previous to the congress, opportunity will be given to foreigners to see New York City under the guidance of some mathematician. The New York World's Fair will probably still be in progress at that time. Excursions to Washington, Niagara Falls and other places will be arranged if there is demand.

Besides the support from Harvard University, the Massachusetts Institute of Technology and other institutions in the neighborhood, generous subventions have been subscribed for by the Carnegie Corporation, the Institute for Advanced Study, the National Research Council and the Rockefeller Foundation.

All persons, whether they expect to be present in person or not, may register for the congress. The fee for regular members is $10.00. These will receive the Proceedings of the congress. Members of families and others not participating in the scientific activities may become associate members, for which the fee is $5.00. Detailed information will be sent in due time to all members of the American Mathematical Society, as well as to all interested persons who file their names in the office of the American Mathematical Society at 531 West 116th Street, New York City.

REPORTS

GRANTS FOR RESEARCH OF THE AMERICAN PHILOSOPHICAL SOCIETY

GRANTS AWARDED FROM THE PENROSE FUND

April, 1938[1]

Frank T. Gucker, Jr., Northwestern University, for technical assistance in determining the heat capacities and heats of dilution of solutions of the simpler amino acids and their uncharged isomers ..... $ 650

Kenneth N. McKee, New York University, for travel and other expenses in connection with the study of the French theater during the Revolutionary period 600

William J. Robinson, New York Botanical Garden, for the study of the condition necessary for the unlimited growth of excised tissues of higher plants, primarily excised root tips 1,500

E. J. Workman and R. E. Holzer, University of New Mexico, to make electrical measurements of the surface field under thunder clouds and charge distributions within the clouds for the purpose of studying quantities of electricity involved in lightning discharges 750

June, 1938

Biological Abstracts, Supplementary support for the publication of abstracts from biological journals of the world 5,000

Edward Girden, Brooklyn College, for supplies in connection with studies on cerebral mechanisms and hearing—localization of the cortical determinants for specific auditory frequencies tested by the L-R discrimination. (2nd grant) 400

Arthur L. Hughes, Washington University, for assistance and apparatus in the study of (a) the distribution of velocities among atomic electrons and (b) conductivity and, in particular, the photoconductivity of insulating liquids and solids 650

Mary R. Haas, Eufaula, Oklahoma, for travel and necessary expenses in making a special field investigation of the history and development of the extant towns which formerly comprised the powerful Creek Confederacy. New information concerning their recent history is to be obtained through a study of the consequences wrought by historic catastrophies (*e.g.,* the Civil War) in which they as well as their white neighbors shared. New information concerning their earlier history to be obtained through a study of the dialectic variations exhibited by the different towns, since the conservatism of language retains evidence of earlier historical connections long after they have passed from memory 1,250

[1] Other grants made in April were announced previously.

William Steel Creighton, College of the City of New York, for the completion of a handbook of North American ants begun in collaboration with the late Dr. W. M. Wheeler 700

William C. Stadie, University of Pennsylvania, for technical assistance in connection with the study of chemical action of insulin upon the intermediary metabolism of isolated, surviving tissue of normal and pathological animals 1,500

William Henry Brown, Johns Hopkins University, for technical assistance in the study of the phylogenetic classification of flowering plants 2,000

Ronald L. Ives, Science Service, for expenses in collecting evidence of glaciation, etc., from reservoir sites of Colorado-Big Thompson Diversion project before they are submerged by water and used as fill in dams, etc. 180

Christianna Smith, Mt. Holyoke College, for technical assistance in (a) the study of age involution of the thymus gland and the analysis of the factors behind the formation of Hassall's corpuscles and (b) the fetal liver during its hematopoietic stage in tissue culture 600

Ludvig Gustav Browman, Montana State University, for equipment for the study of oestrous and activity rhythms, and reproductive behavior of rats born and kept in constant darkness as contrasted with those kept in constant light 260

Josiah Cox Russell, University of North Carolina, for travel and other expenses in connection with studies in the history of the population of Medieval England 1,500

R. T. Hill, Indiana University School of Medicine, for technical assistance and supplies in an investigation of the androgenic function of ovaries 1,000

Carl C. Lindegren, University of Southern California, for technical assistance in the analysis of the mechanism of crossing-over by growing to maturity the plants produced from the spores of *Neurospora crassa.* (2nd grant) 500

Martin Kilpatrick, University of Pennsylvania, for research assistant and materials for the determination of relative acid strengths in aqueous and non-aqueous solutions 1,000

Frank E. E. Germann, University of Colorado, for technical assistance and supplies in the study of anomalous double refraction observed by Germann and Metz of solutions of certain inorganic salts in water to determine whether the effect is due to ions or to molecules formed by hydrolysis 2,000

Jean Broadhurst, Columbia University, for technical assistance and apparatus in the development of a virus test for scarlet fever susceptibility and immunity 1,750

C. L. Turner, Northwestern University, for field work in Mexico on the study of viviparity in teleost fishes; evolution of structures associated with viviparity in the family of Goodeidae, a group of fishes confined to the Mexican Plateau and adjacent regions 250

Horace G. Richards, New Jersey State Museum, for travel expenses in connection with the collection of land and fresh-water mollusks from the Corn Islands, Nicaragua, and adjacent mainland; study of these mollusks with particular attention to their bearing on problems of paleography. (3rd grant) 250

S. C. Brooks, University of California, for assistance in the study of the penetration of alkali and alkaline-earth metal ions and halides as a function of time and concentration, and metabolism of the protoplasm and sap of living plant cells 200

Philadelphia Institute for Medical Research, for assistance and supplies in the continuation of studies, through succeeding generations of the role of the thymus in the rate of growth and development of the young. (4th grant) 2,000

Peter J. Rempel, University of Southern California, for field work assistance, etc., in the study of several plant associations, namely, conifer forest, chaparral, pinyon pine woodland and desert, on the desert side of the San Jacinto and Santa Rosa ranges, California, and in chaparral on the seaward side of the same mountains, with respect to the differences in their environmental complexes and the phytometric responses in growth occasioned by these, with a view to elucidate some of the reasons for the vegetational differences 500

Donald Young Solandt, University of Toronto, for apparatus in an experimental study of the accommodation process in the excitation of irritable tissues with special reference to the excitation of single cells of such tissues 350

Nathaniel E. Griffin, Cambridge, Mass., for support of an investigation of the sources and influence of the "Historia Destructionis Troiae" of Guido de Columnis (to form Volume 2 in a 3-volume edition of this work) 500

October, 1938

Montague Francis Ashley-Montagu, Hahnemann Medical College, for travel and clerical assistance in a study of the development of interest in the comparative anatomy of the Primates as illustrated by the life and work of Edward Tyson (1650–1708) 400

Gaylord P. Harnwell, University of Pennsylvania, for the construction of a new type of β-ray spectrograph to investigate the β-ray spectra of electron-emitting and positron-emitting radio-elements 1,000

Roberts Rugh, Hunter College and Columbia University, for assistance and supplies for: (1) comparative study of the morphology and physiology of the urino-genital systems of Amphibia; (2) study of the effect of hypophysectomy on the testis of the immature and mature bullfrog; and (3) study of the susceptibility of frog gametes to x-radiation prior to and subsequent to fertilization 350

Astronomical Hollerith-Computing Bureau, Columbia University, for assistance and materials in the preparation of a punched card catalogue of the data contained in the Boss General Catalogue of 33,342 stars and of other quantities derived from these 1,200

Jacob Klein, St. John's College, Annapolis, for a close study of classical physics, its problems, principles and origins starting from the work of Galileo 1,200

J. Bennett Nolan, Reading, Pa., for clerical assistance in the preparation of an annotated edition of the diary of Henry Marchant (1741–1796) 100

Jean Piatt, University of Vermont, for assistance and apparatus in an investigation of the factors underlying the anatomical and physiological specificity which exist between any given muscle and the nerve which supplies it; the nerve-muscle specificity problem 500

Malcolm Dole, Northwestern University, for technical assistance in a study of the effect of negative ions on the glass electrode 800

Karl F. Herzfeld, Catholic University of America, for a research associate in an experimental investigation of the physical theory of the connection between molecular structure and the absorption spectrum of organic compounds. (2nd grant) 1,200

Thomas Hume Bissonnette, Trinity College, Hartford, for assistance and supplies in an investigation of sexual photoperiodicity in animals and related phenomena 1,000

Harry Richard Seiwell, Woods Hole Oceanographic Institution, for an assistant in the investigation of internal waves in the North Atlantic Ocean ... 1,200

T. M. Sonneborn, Johns Hopkins University, for technical assistance in the study of the genetics of Paramecium—the analysis of the mechanism of inheritance, particularly inheritance of mating type. (2nd grant) 900

Fred A. Berkley, Montana State University, for travel and supplies for a bibliographical and herbarium study in preparation of a monograph of the Anacardiaceae (Sumac family) 550

R. G. Herb, University of Wisconsin, for supplies in connection with studies in nuclear physics by means of a 2.4 million volt electrostatic generator 400

Fred E. D'Amour, University of Denver, for technical assistance and supplies in connection with the study of the endocrine control of ovulation and related physiologic changes. (2nd grant) ... 1,000

E. B. Babcock, University of California, for technical assistance in the cytogenetic investigations in the Cichorieae and their bearing on taxonomy, phylogeny and evolution of the higher plants 400

Eliot R. Clark, University of Pennsylvania, for technical assistance in the continuation of the study of the growth and behavior of various cells, tissues and organs as observed microscopically in the living mammal, with the aid of permanently installed transparent chambers and windows. (2nd grant) 300

Robley D. Evans, Massachusetts Institute of Technology, for technical assistance, equipment and supplies for an international interchecking program to evaluate, correlate and extend the scattered knowledge of the radioactivity of natural materials 3,000

Arthur M. Banta, Brown University, for a research assistant in the study of the effect of the characters (phenotype) of the mothers upon the characters (phenotype) of her offspring, apart from her genetic constitution (genotype) 1,200

Gregory Pincus, Clark University, for a research assistant in the study of metabolism of rabbit eggs and embryos in different inbred strains and in hybrids between them, with particular reference to the metabolic basis of size differences in early ova 1,200

Nabih Amin Faris, Princeton University, for photographic supplies and photostats for a critical and comparative study of the Arabic calligraphy based on old manuscripts, with a view to determining the development of the Arabic characters, diacritical points and vowel signs 300

Edwin R. Helwig, University of Pennsylvania, for African travel expenses in connection with the study of the phylogenetic history of the chromosome complex in the Orthoptera 350

John Edward Dinsmore, Herbarium of the American Colony, Jerusalem, Palestine, for travel and technical assistance in a study of the taxonomy of the iris in Syria and Palestine and the discovery of new species 300

GRANTS AWARDED FROM THE ELDRIDGE REEVES JOHNSON FUND

Academy of Natural Sciences of Philadelphia:

Geology and Paleontology Department, for assistance in the study of type and undescribed specimens of fossils in the academy's collection in preparation for the making of a published, annotated and illustrated list of such specimens, including new material not heretofore described or illustrated 3,580

Henry W. Fowler, for the publication of a report on the fishes obtained by the George Vanderbilt South Pacific Expedition of 1937, comprising over 25,000 specimens, new species, rare or little known forms, besides extensive items in distribution, variation, taxonomy, etc. Publication to be a number of the "Monograph" series of the academy 1,500

Samuel George Gordon, for travel expenses in making a mineralogical survey of the Atacama Desert, Chile 920

Francis W. Pennell, for travel expenses, photography, etc., in making a study of the Scrophulariaceae of Western Temperate North America on a taxonomic, geographic and phylogenetic basis 500

H. Radclyffe Roberts, for field work and transportation in making a distributional and taxonomic study of the Orthoptera of Mexico and especially their relation to the Orthopteran fauna of the United States 500

University Museum, University of Pennsylvania:

Alan Rowe, for printing and editorial work in the publication of his manuscript, "The Four Canaanite Temples of Beth Shan." This volume deals with the temples of Rameses II, Seti I and Amenophis III excavated by the Palestinian Expedition at Beth Shan 2,500

V. J. Fewkes, for printing and editorial work in the publication of his manuscript "Excavations at Homolka," a final report of the completed investigation of an aneolithic fortified camp site in Czecho-Slovakia with an occupation period of several hundred years 1,000

H. U. Hall, for printing and editorial work in the publication of his manuscript entitled "Studies of the Sherbro Tribe, Sierra Leone," a report of the expedition to Sierra Leone, West Africa, conducted during 1936–37 1,000

Frederica de Laguna and Kaj Birket-Smith, for printing and editorial work in the publication of their manuscript entitled "Ethnology of the Eyah Indians of Alaska," covering ethnological material obtained by a joint expedition of the University Museum and the Danish National Museum in 1933 1,200

J. Alden Mason and Linton Satterthwaite, Jr., for architectural and editorial work in the completion of their manuscript and architectural drawings for their report entitled "Excavations at Piedras Negras," a final publication of seven years' work at the site of the ancient Maya city of Piedras Negras, Guatemala, including architectural studies of the temples and palaces which have been uncovered by the expedition as well as studies of the artistic and historical material found at the site 1,300

Eldridge Reeves Johnson Foundation for Medical Physics, University of Pennsylvania:

Leslie A. Chambers and J. B. Bateman, for mate-

rial, equipment and technical assistance in the study of the molecular organization of cell surfaces in relation to biological activity and specificity 1,500

Detlev W. Bronk, for material, equipment and assistance in the study of the mechanism of chemical excitation of nerve cells 1,800

Detlev W. Bronk, for material, equipment and assistance in making a general investigation of the nervous control of body organs in terms of the properties of nerve cells and fibers which make up the sympathetic and para-sympathetic nervous systems; with special reference to the physico-chemical processes which occur within these systems 2,050

H. K. Hartline, for material and equipment in connection with the study of the photo-chemical and neural processes of vision 1,500

SPECIAL ARTICLES

IDENTIFICATION OF THE FILTRABLE, TRANSMISSIBLE NEUROLYTIC AGENT ISOLATED FROM TOXOPLASMA-INFECTED TISSUE AS A NEW PLEUROPNEUMONIA-LIKE MICROBE

THE isolation from Toxoplasma-infected tissues of a filtrable, transmissible agent capable of producing a characteristic nervous disease in mice was reported recently.[1] The nature and origin of this agent was perplexing because (a) it was not demonstrated in thousands of normal mice, (b) it did not appear to possess the properties necessary for natural host-to-host transmission either by itself or by means of an arthropod vector, and (c) it appeared to be intimately associated with certain strains of Toxoplasma. The morphological appearance of the minute structures observed intracellularly and extracellularly in some of the infectious material suggested a similarity (a) to "chromatin" structures within the Toxoplasma and (b) to stages described for the causative agents of pleuropneumonia and agalactia. The relationship to "chromatin" structures of Toxoplasma, admittedly a fantastic concept, was rendered even more so by the finding that they were Feulgen-positive, while the structures in the "neurolytic agent" material were Feulgen-negative. The relationship to the causative agents of pleuropneumonia and agalactia appeared unlikely at first because their minimal size of 125–150 mμ and their capacity to grow in a cell-free medium containing serum differentiated them from the neurolytic agent material which appeared to have a minimal size of 314 to 360 mμ and failed to grow in serum-containing media.

By a modification of technique, however, it has proved possible to grow the "neurolytic agent" in a cell-free medium, consisting of ordinary nutrient broth, 10 per cent. Seitz-filtered, sterile, bovine serum and 0.5 per cent. glucose. No growth was perceptible in the initial cultures, but one or two transfers of the apparently negative cultures to fresh medium invariably showed a faint opalescence which, upon dark-field examination, revealed structures not unlike those seen in "neurolytic-agent" infectious material. Successful cultures were thus obtained from each of six infectious brains—some of which had been kept in the dried state for months and others fresh—while simultaneous tests with the same medium to which no glucose was added failed in a number of instances; in the absence of serum, all attempts were negative. Subculture of the serum-glucose-broth cultures on serum-agar yielded colonies 20 to 100 μ in size, which on direct microscopic observation and study of Giemsa-stained impression films were quite similar to those described by Ledingham[2] for pleuropneumonia and agalactia. The evidence that the cultivated microorganisms are identical with the "neurolytic agent" is as follows:

(1) More than 18 subcultures have now been obtained, and the cultures continue to show in mice the same pathogenic effects (both clinical and pathological manifestations) as the animal-passage material.

(2) The active agent is filterable, although with culture material a smaller size was obtained for the minimal infectious particle (determined by animal inoculation as well as by culture), *i.e.*, 250 to 292 mμ instead of 310 to 360 mμ.[3]

(3) Its pathogenicity is inactivated at the same temperature (about 45° C. for 15 minutes).

(4) The cultivated and animal-passage materials give rise to complete immunity against each other.

Elaboration of exotoxin in vivo and in cultures: In the first report[4] it was indicated that the brain lesions produced after intraperitoneal or intrathoracic inoculation were not caused by the transmissible agent itself but rather by some non-transmissible substance formed when growth occurred in certain sites. Filtration of cultures through Seitz filters, which hold back the infective particles, yielded a material which upon intravenous injection (but not intracerebral or intraperitoneal) of 0.5 cc amounts in 3-weeks-old mice (old mice react irregularly or not at all), reproduced the typical nervous signs within 1 to 2 hours. Most of these mice died within a few hours, but the surviving ones continued with the nervous signs and exhibited

[1] A. B. Sabin, SCIENCE, 88: 189, 1938.

[2] J. C. G. Ledingham, *Jour. Path. Bact.*, 37: 393, 1933.

[3] Gradocol membranes and filters were kindly supplied by Dr. J. H. Bauer.

[4] A. B. Sabin, *loc. cit.*

the same acute necrotic lesion in the posterior pole of the cerebellum, with acidophilic necrosis of Purkinje cells, so often observed in virus affections, which has already been described.[5] Neither the brain nor the viscera of these mice contained a transmissible agent.

The toxin is produced early during growth, is present in very small amounts, and disappears from the culture within 2 days of its appearance. It is thermolabile, being inactivated at 50° C. but not at 45° C. for one-half hour. It is apparently antigenic and the same as that produced *in vivo* during infection, since recovered mice are immune to it.

Natural habitat and transmission: Previous attempts to isolate a similar agent from thousands of normal mice by animal inoculation and subinoculation failed. A new attempt was made by the technique of cultivation and subcultivation just described. The viscera and brains of ten 1-month-old mice from the normal stock were cultured separately with negative results in the initial culture tubes, but on transfer to fresh medium, a pure culture of a pleuropneumonia-like microbe was obtained from the brain but not from the viscera (liver, spleen, lung) of one of the mice. This strain has been repeatedly subcultured since, and still requires serum although not the added glucose for its growth. It is not, however, pathogenic for mice, several passages in mice have not yet made it so, and no toxin has been found in its cultures. Since the cultivated as well as the animal-passage material does not appear to be capable of multiplication in the peripheral sites which permit of direct host-to-host transmission by means of an arthropod vector, it is necessary to consider the possibility of a new type of vector for these microorganisms, namely, bacterial or perhaps even protozoal. Klieneberger[6] has already shown the existence of a pleuropneumonia-like microorganism in natural symbiosis with a streptobacillus and has also experimentally induced a symbiosis with *B. tetani* and *B. tetanomorphus*. The intimate association of the present pleuropneumonia-like microbe with Toxoplasma may perhaps be another form of symbiosis resulting from a chance encounter in normal mice, maintained by repeated passage with a consequent development of the special pathogenic properties in what might originally have been a non-pathogenic pleuropneumonia-like microorganism. I have been informed by Dr. G. M. Findlay that he has encountered a similar disease among mice in London in the course of routine passage of the yellow fever and lymphocytic choriomeningitis viruses and that Dr. E. Klieneberger has isolated a pleuropneumonia-like microorganism from the material. He has compared the infective agent from English mice with that of mice which I sent him and found that the two were essentially similar and immunologically identical.[7]

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THE LIFE-MAINTAINING EFFECT OF CRYSTALLINE PROGESTERONE IN ADRENALECTOMIZED FERRETS[1]

IN the dog, ferret and cat the condition of pseudopregnancy prevents the appearance of adrenal insufficiency following adrenalectomy. Estrus, contrariwise, increases the need for cortical hormone therapy. Somewhat similar but less striking results occur in the rat. Thorn and Harrop found resemblances between cortical extracts and several sex hormones on electrolyte excretion of intact dogs. The chemical similarity between cortical substances and progesterone suggests that the latter might be the life-maintaining agent during pseudopregnancy, but direct tests in several laboratories have failed to demonstrate it. Furthermore, the estrogens which have an effect like progesterone and cortical hormone in intact dogs are toxic in adrenalectomized rats.[2]

With the idea that dosage or species variables may have been the cause of previous failures to maintain life, we have investigated the effect of progesterone and other sex hormones in adrenalectomized ferrets.[3]

Anestrus adrenalectomized ferrets fed a diet of fresh milk and fresh, ground, lean meat, to which is added a 2 per cent. Na-salt supplement, demand, with a good uniformity, one cc of cortical extract per day (equivalent of 30 gms fresh adrenal tissue) for maintenance. Without therapy adrenal insufficiency (loss of weight, anorexia and asthenia) occurs on the average (of 15 cases) at 6 days with a range of 3 to 10 days. During estrus the cortical hormone requirement is at least doubled.

The effect of prolonged progesterone treatment on adrenalectomized ferrets has been observed in six instances on five animals. Ovariectomized and non-ovariectomized females and one castrate male were used. With adequate dosage all signs of adrenal insufficiency were prevented for the duration of treatment, or, as occurred in three cases, when dosage was reduced to inadequate levels so that adrenal insufficiency appeared, revival to excellent health was effected by giving 5 mgm progesterone daily without any cortical hormone. Treatment was continued for 32 days in

[5] *Ibid.*

[6] E. Klieneberger, *Jour. Path. Bact.*, 40: 93, 1935; *Jour. Hyg.*, 38: 458, 1938.

[7] To be reported in a forthcoming issue of *Lancet*.

[1] This work was aided by a grant (to R. G.) from the Penrose Fund of the American Philosophical Society.

[2] Most references to above work are cited by R. Gaunt, *Cold Spring Harbor Symp. Quant. Biol.*, 5: 395, 1937.

[3] The authors are indebted to Dr. W. W. Swingle, of Princeton University, for the cortical extract used here and for other assistance; and to Dr. Erwin Schwenk, of the Schering Corporation, who furnished the progesterone (Proluton) and testosterone propionate (Oreton).

two cases, 30 days in one, 20 days in two and 14 days in another. Apparently life could have been maintained indefinitely with continued treatment. Dosages used varied from 0.5 to 5 mgm per day. The former was ineffective and the minimal life-maintaining dose seemed to be approximately 2 mgm per day. Marked weight gains occurred during treatment in 5 of 6 cases. The salt supplement usually added to the meat diet was not essential for the observed effects as determined by its omission in one case. All animals died of adrenal insufficiency when therapy was discontinued, showing that adrenalectomy was complete.

In two cases a commercial corpus luteum extract from hog ovaries proved toxic and reduced the life-span, perhaps because of estrin contamination.

Testosterone propionate, a substance chemically and in some ways biologically similar to progesterone, was slightly, if at all, effective in four animals, in doses of 5 or 10 mgm per day. The animals lived for 13, 12, 8 and 11 days. Similar results have been obtained in rats by others. Estrone given to two animals in doses of 0.1 and 0.2 mgm daily was toxic, as in the rat, and as was to be inferred from the effects of spontaneous estrus.

CONCLUSIONS

Crystalline progesterone will maintain adrenalectomized ferrets in excellent health and will relieve an established adrenal insufficiency. The phenomenon of life-maintenance in pseudopregnant adrenalectomized animals is therefore probably explained on the basis of progesterone secretion alone. Testosterone is non-toxic and non-beneficial to adrenalectomized ferrets, while estrone is toxic.

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NICOTINIC ACID AND THE GROWTH OF ISOLATED PEA ROOTS[1]

IN earlier publications[2,3] it has been shown that vitamin B_1 is an essential accessory factor for the growth of isolated pea roots. Pea roots were maintained for 14 weekly transfers in a medium containing only vitamin B_1 in addition to sucrose and mineral nutrients. It was also shown, however, that the growth rate of isolated pea roots decreases in successive transfers if vitamin B_1 is the only accessory growth factor. Such roots also become progressively thinner as the weekly transfers are continued. Vitamin B_1 alone is not then the only growth factor essential for the sustained growth of the isolated pea root. Other investigators have suggested that specific minor elements[4,5] or specific "essential" amino acids[6] constitute this second essential growth factor in the case of the isolated tomato root. The present authors also found that a mixture of 16 amino acids possessed activity as the second growth factor for the isolated pea roots.[7] The mixture of amino acids used in these earlier experiments was, however, a purely arbitrary one. In work which will be described in detail elsewhere, each individual amino acid was tested both alone and in combination with other amino acids (always in the presence of added vitamin B_1) for its ability to increase the growth of the isolated pea root above the level of growth rate of similar roots supplied with only vitamin B_1 as the accessory factor. In this way a mixture of amino acids having the composition shown in Table 1 and optimal for support of the growth rate of the isolated pea root was obtained. This mixture of amino acids was found capable of increasing the growth rate of isolated pea roots over the growth rate obtained with vitamin B_1 alone, but to be incapable of supporting growth at an undiminished rate for more than three weekly transfers. It is clear then that the second factor limiting the growth of isolated pea roots is not merely a combination of amino acids. It has also been found that the factor in question is not a specific minor element.

TABLE 1

AMINO ACID MIXTURE OPTIMAL FOR THE GROWTH OF PEA ROOTS

Amino acid	Concentration in medium in mg. per liter
Asparagine	0.1
Glycine	0.05
Glutamic Acid	0.5
Isoleucine	0.015
Leucine	0.5
Tryptophane	0.5
Valine	0.05

Nicotinic acid, in combination with vitamin B_1, exerts a very striking effect on the growth of the isolated pea root, as is demonstrated by the following experiment. Approximately 700 pea roots, which had been in culture on vitamin B_1 free medium for one week, were divided into 7 series. These separate series received as accessory growth factors either vitamin B_1, the amino acid mixture, nicotinic acid or combinations of these. The series receiving only vitamin B_1 will be considered the control. It may be seen in Table 2 that in all series in which nicotinic acid and vitamin B_1 were not both present there was a steady decrease of

[1] Report of work carried out with the assistance of the Works Progress Administration, Official Project No. 665-07-3-83, Work Project W-9809.

[2] J. Bonner, SCIENCE, 85: 183–184, 1937.

[3] J. Bonner and F. T. Addicott, *Bot. Gaz.*, 99: 144–170, 1937.

[4] W. J. Robbins and M. Bartley, SCIENCE, 85: 246–247, 1937; *Bot. Gaz.*, 99: 671–728, 1938.

[5] P. R. White, *Plant Physiol.*, 13: 391–398, 1938.

[6] *Ibid.*, 12: 793–802, 1937.

[7] J. Bonner and F. T. Addicott, *loc. cit.*

TABLE 2

EFFECT OF VITAMIN B_1, NICOTINIC ACID (0.5 MG PER LITER) AND "PEA ROOT AMINO ACID MIXTURES" DONE IN COMBINATION, ON THE GROWTH OF ISOLATED PEA ROOTS

Growth factors added	Growth in mms per week, average for 2 weeks		
	II and III	IV and V	VI and VII
B_1	41.1	23.6	11.6
Amino acids	32.5	22.1	5.9
Nicotinic acid	45.8	25.0	9.2
Nicotinic and amino acids	46.3	18.4	16.2
B_1 and amino acids	47.0	30.1	20.1
B_1 and nicotinic acid	55.8	70.6	72.6
B_1, nicotinic acid and amino acids	54.2	68.6	77.7

growth rate with each weekly transfer. Nicotinic acid alone, however, supported growth of the isolated pea root at least as well as did vitamin B_1. Combination of the amino acid mixture with either nicotinic acid or with vitamin B_1 supported the growth at a somewhat higher level than did either substance in the absence of the amino acid mixture. Combination of nicotinic acid with vitamin B_1 or with vitamin B_1 and the amino acid mixture, on the other hand, resulted in a steady increase of growth rate. This increase has been found in several different experiments and is of the order of 50 per cent. above the initial level. Although the experiment recorded in Table 2 was maintained through only 7 weekly transfers, a second experiment was maintained through 10 weeks with undiminished rate of growth of the roots which received nicotinic acid in addition to vitamin B_1 and the amino acid mixture (Fig. 1). Such roots were indistinguishable in appearance (except for their greater length) from roots which had been but 2 weeks in culture.

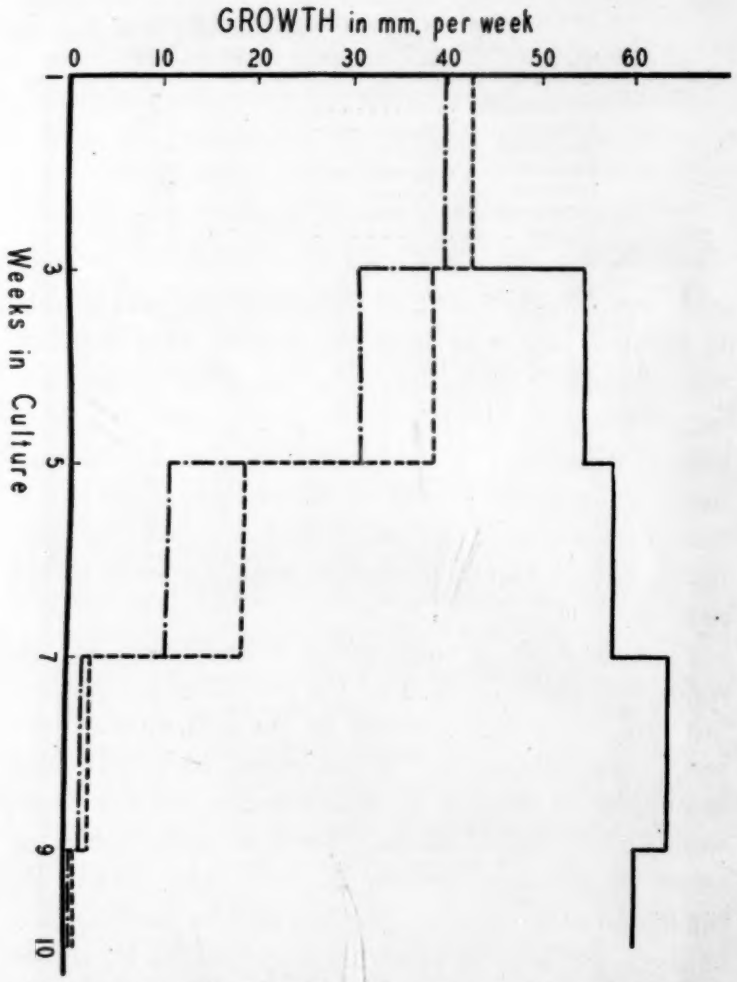

FIG. 1. Growth of isolated pea roots with and without nicotinic acid in addition to vitamin B_1 and the optimum mixture of amino acids: Solid line, nicotinic acid plus vitamin B_1 plus amino acids; dotted line, vitamin B_1 plus amino acids; dot and dash line, vitamin B_1 alone. Nicotinic acid was introduced into the medium of part of the series which had been cultured in vitamin B_1 and amino acids at the end of the third week. No accessory growth substances are added to the roots during the first week.

Although the data presented (in Table 2) do not yet permit of a definitive decision, still it seems possible that the amino acid mixture is not essential to the continued optimal growth of isolated pea roots. Nicotinic acid, however, must apparently be regarded as a factor quite as significant as vitamin B_1 in the nutrition of the isolated pea root. The promotive influence of nicotinic acid on the shoot growth of the isolated pea embryo[8] also must in all probability be attributed to the effect of this substance on the growth of the root.

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[8] J. Bonner, *Plant Physiol.*, in press.

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